Scale dependent bias from an inflationary bispectrum: the effect of a stochastic moving barrier

Matteo Biagetti

University of Geneva

Based on: MB & Desjacques, arXiv: 1502.04982

Motivation

From my talk @ Swiss Cosmodays 2013 in Bern
(before Planck 2013 release)

- *Primordial non-Gaussianity is a key-feature to discriminate among all the models of inflation*

- *New constraints on (or detection of) primordial non-Gaussianity are coming soon from Planck satellite. Improving these constraints will be a challenge of the LSS physics (ex. EUCLID).*

Motivation

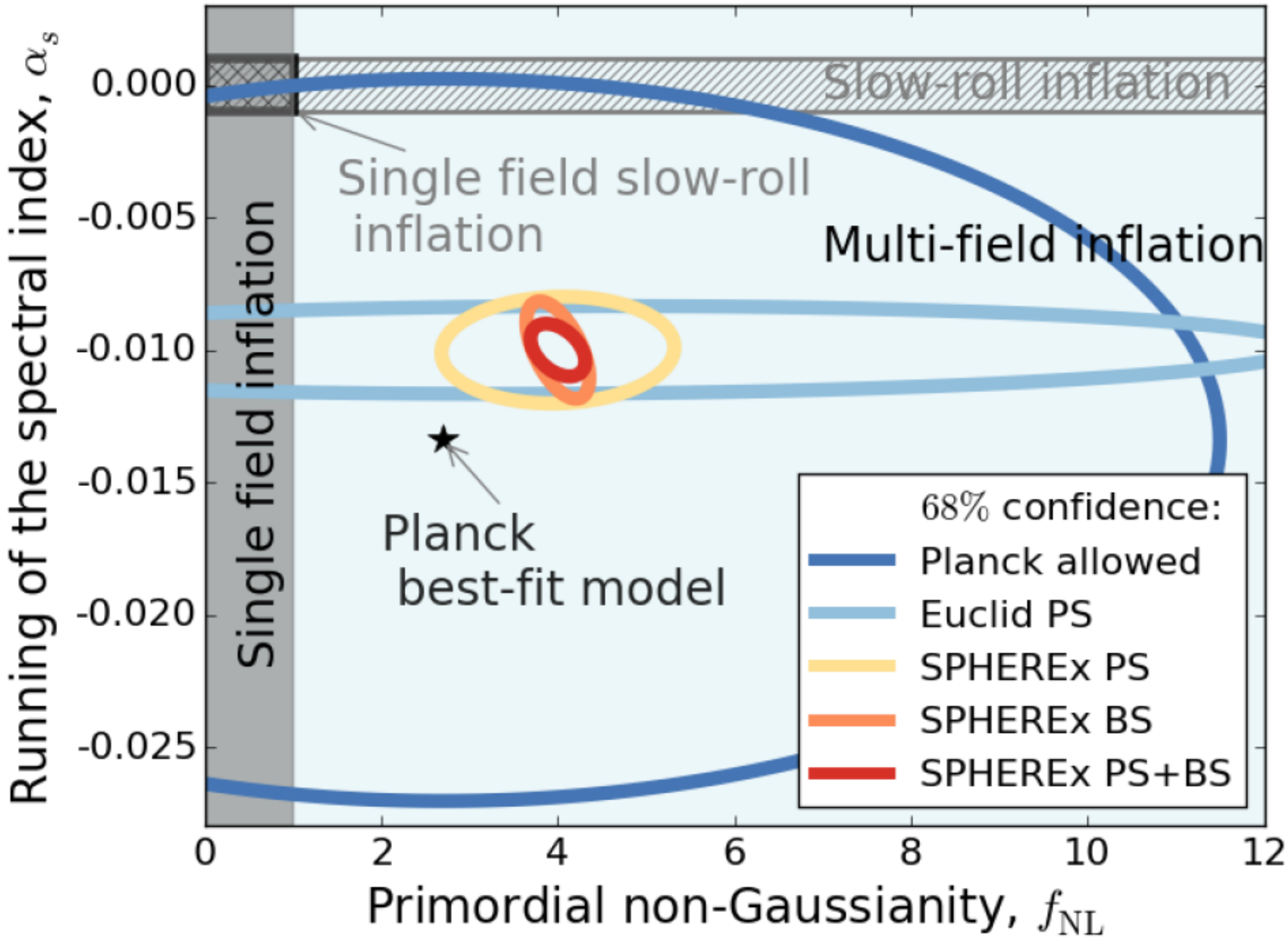
Today
(after Planck 2015 release)

- Primordial non-Gaussianity is a ***still*** key-feature to discriminate among all the models of inflation

$$f_{\mathrm{NL}}^{\mathrm{local}} = 0.8 \pm 5.0 \qquad @\,68\%\,\mathrm{CL}$$

Planck 2015 results. XVII. Primordial non-Gaussianity, arXiv:1502.01592

Motivation



SPHEREx: An all sky spectral survey, Doré et al., arXiv: 1412.4872
MB, Kehagias & Riotto, arXiv: 1502:XXXXX to appear next week

Motivation

Today
(after Planck 2015 release)

- Improving these constraints *is now* a challenge of the LSS physics (ex. EUCLID).

$$P_g(k) = \Big(b_1 + \Delta b_1(k)\Big)^2 P_m(k)$$

$$\Delta b_1(k) \propto 2 f_{\rm NL} \frac{b_{\rm NG}}{k^2}$$

Dalal, Doré, Huterer & Shirokov, Phys. Rev. D, 77, 123514 (2008)

Motivation

Today
(after Planck 2015 release)

We need a deep theoretical understanding of the signatures imprinted by primordial non-Gaussianity on the LSS

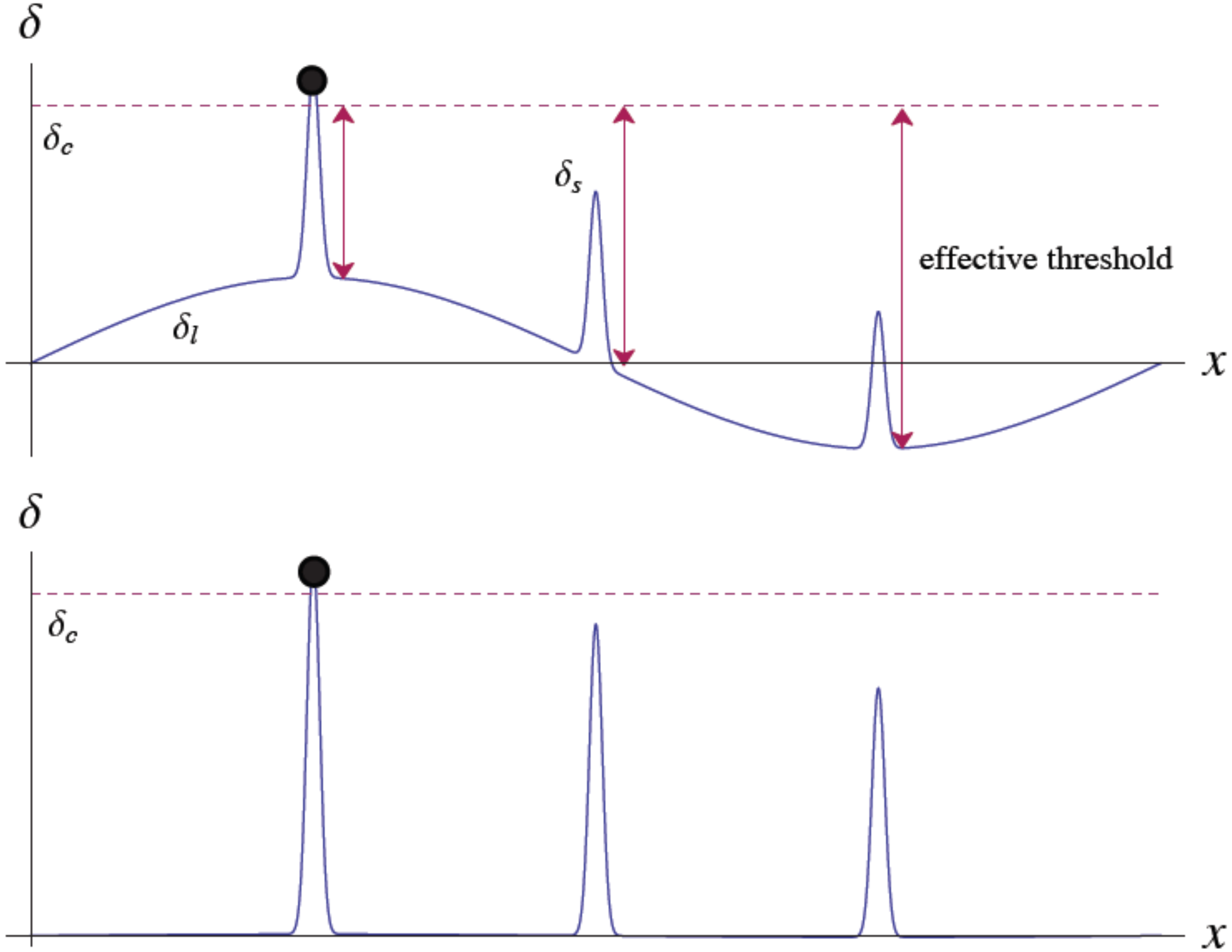
$$P_g(k) = \Big(b_1 + \Delta b_1(k)\Big)^2 P_m(k)$$

$$\Delta b_1(k) \propto 2 f_{\rm NL} \frac{b_{\rm NG}}{k^2}$$

Dalal, Doré, Huterer & Shirokov, Phys. Rev. D, 77, 123514 (2008)

First step: galaxy biasing

Peak Background Split ansatz: $\delta = \delta_{\rm L} + \delta_{\rm S}$



$\Delta b_1(k) \propto 2 f_{\rm NL} \frac{b_{\rm NG}}{k^2}$

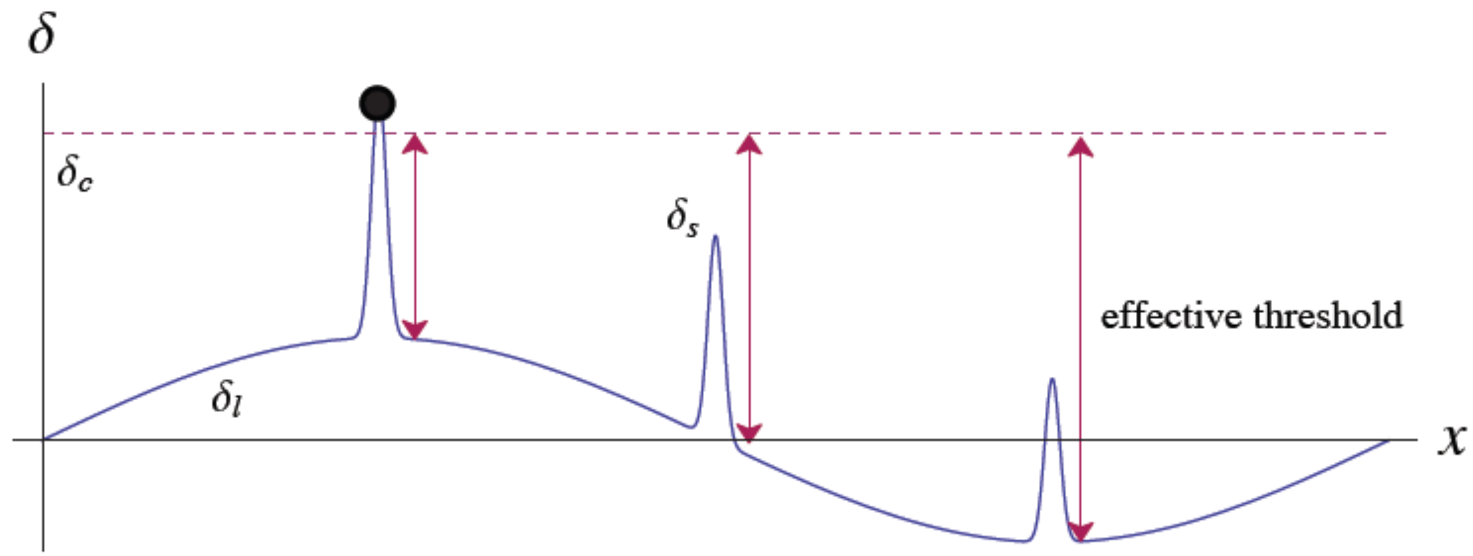
Credits: Tada & Yokoyama, arXiv: 1502.01124

First step: galaxy biasing

The effect of the long-wavelength field is to modulate locally the threshold for collapse

$$\delta_g(\vec{x}, M, \delta_c) \equiv \frac{n_g(\vec{x}, M, \delta_c)}{\bar{n}_g(M, \delta_c)} - 1 \approx \frac{\bar{n}_g(M, \delta_c - \delta_{\rm L}(\vec{x}))}{\bar{n}_g(M, \delta_c)} - 1$$

$$\approx -\frac{1}{\bar{n}_g}\frac{d\bar{n}_g}{d\delta_c}\delta_{\rm L}(\vec{x}) + \ldots$$



$$\Delta b_1(k) \propto 2 f_{\rm NL}\frac{b_{\rm NG}}{k^2}$$

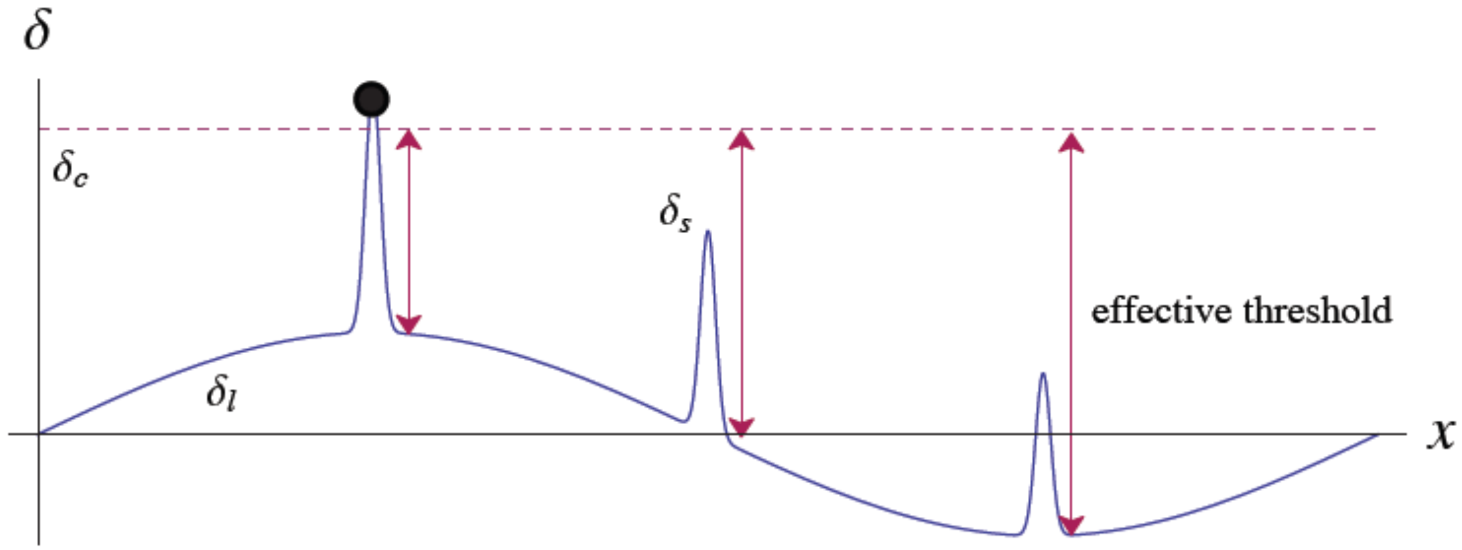
First step: galaxy biasing

The effect of the long-wavelength field is to modulate locally the threshold for collapse

$$\delta_g(\vec{x}, M, \delta_c) \equiv \frac{n_g(\vec{x}, M, \delta_c)}{\bar{n}_g(M, \delta_c)} - 1 \approx \frac{\bar{n}_g(M, \delta_c - \delta_{\rm L}(\vec{x}))}{\bar{n}_g(M, \delta_c)} - 1$$

$$\approx -\frac{1}{\bar{n}_g}\frac{d\bar{n}_g}{d\delta_c}\delta_{\rm L}(\vec{x}) + \ldots$$

b_1



$\Delta b_1(k) \propto 2 f_{\rm NL} \frac{b_{\rm NG}}{k^2}$

Second step: adding PNG

Local quadratic non-Gaussianity $\Phi = \phi_{\rm G} + f_{\rm NL}\phi_{\rm G}^2$

PBS ansatz

$$\Phi = \phi_{\rm L} + f_{\rm NL}\phi_{\rm L}^2 + (1 + 2f_{\rm NL}\phi_{\rm L})\phi_{\rm S} + f_{\rm NL}\phi_{\rm S}^2$$

This separation leads to

$$\delta_{\rm L} = \mathcal{M} \star \Phi_{\rm L} \approx \mathcal{M} \star \phi_{\rm L} \qquad \delta_{\rm S} = \mathcal{M} \star \Phi_{\rm S} \approx \mathcal{M} \star (1 + 2f_{\rm NL}\phi_{\rm L})\phi_{\rm S}$$

being $\mathcal{M}(k) = \dfrac{2}{3}\dfrac{k^2 T(k) D(z)}{\Omega_m H_0^2}$

$\Delta b_1(k) \propto 2f_{\rm NL}\dfrac{b_{\rm NG}}{k^2}$

Second step: adding PNG

Long- and short-wavelength modes are now mixed, the effect is to modify the amplitude of the matter fluctuations

$$\sigma_8 \to (1 + 2 f_{\rm NL} \phi_{\rm L}) \sigma_8 = \hat{\sigma}_8$$

so that

$$\delta_g(\vec{x}, M, \delta_c) \approx b_1\, \delta_{\rm L}(\vec{x}) + 2 f_{\rm NL} \frac{\partial \ln \bar{n}_h}{\partial \ln \hat{\sigma}_8} \phi_{\rm L}(\vec{x}) + \ldots$$

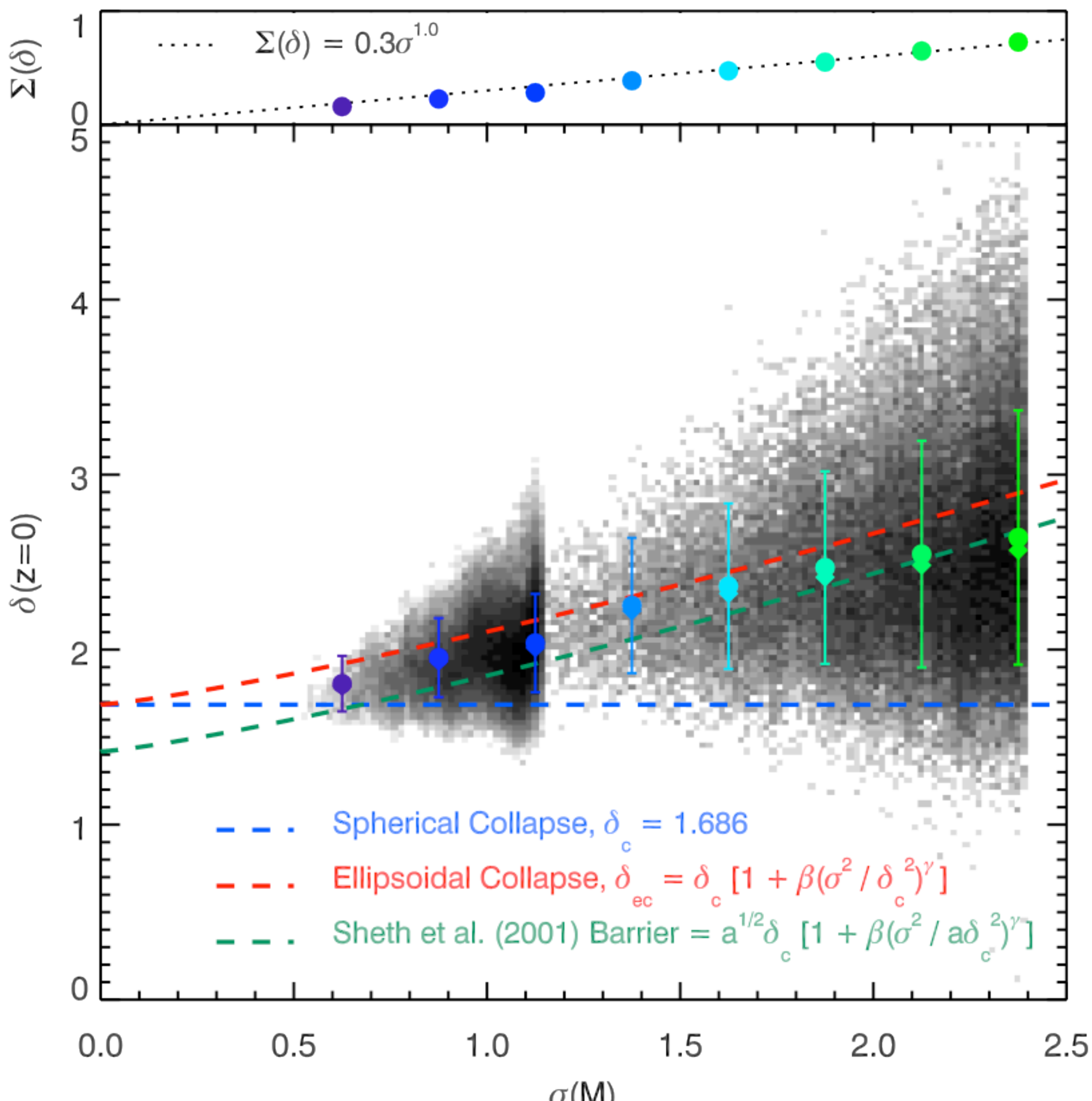
$$\equiv b_{\rm NG}^{\rm PBS}$$

<u>Assuming:</u>

$\boxed{\text{constant barrier for threshold collapse}}$

$\Delta b_1(k) \propto 2 f_{\rm NL} \frac{b_{\rm NG}}{k^2}$

Third step: moving barrier



$$\Delta b_1(k) \propto 2 f_{\rm NL} \frac{b_{\rm NG}}{k^2}$$

Robertson et al., APJ 696,636 (2009)

Fourth step: Excursion Set Peaks

- **Peak model**: consider density peaks of the early distribution of matter and move them forward in time;
  Bardeen et al., Astrophys.J. 304 (1986) 15-61

- (Most) **halos will form around initial peaks**;
  Ludlow & Porciani, MNRAS 413,1961 (2011)

- Impose that **peaks** on a given smoothing scale are **counted only if they satisfy a first crossing condition.**
  Paranjape, Lam & Sheth, MNRAS 420, 1429 (2012)
  Paranjape, Sheth & Desjacques, MNRAS, 431, 1503 (2013)

$$\Delta b_1(k) \propto 2 f_{\rm NL} \frac{b_{\rm NG}}{k^2}$$

Fourth step: ESP

The ESP halo mass function reads

$$\bar{n}_{\rm h} = \frac{\bar{\rho}}{M^2}\nu_c f_{\rm esp}(\nu_c, R_T)\frac{d\log\nu_c}{d\log M}$$

where we define a stochastic moving barrier

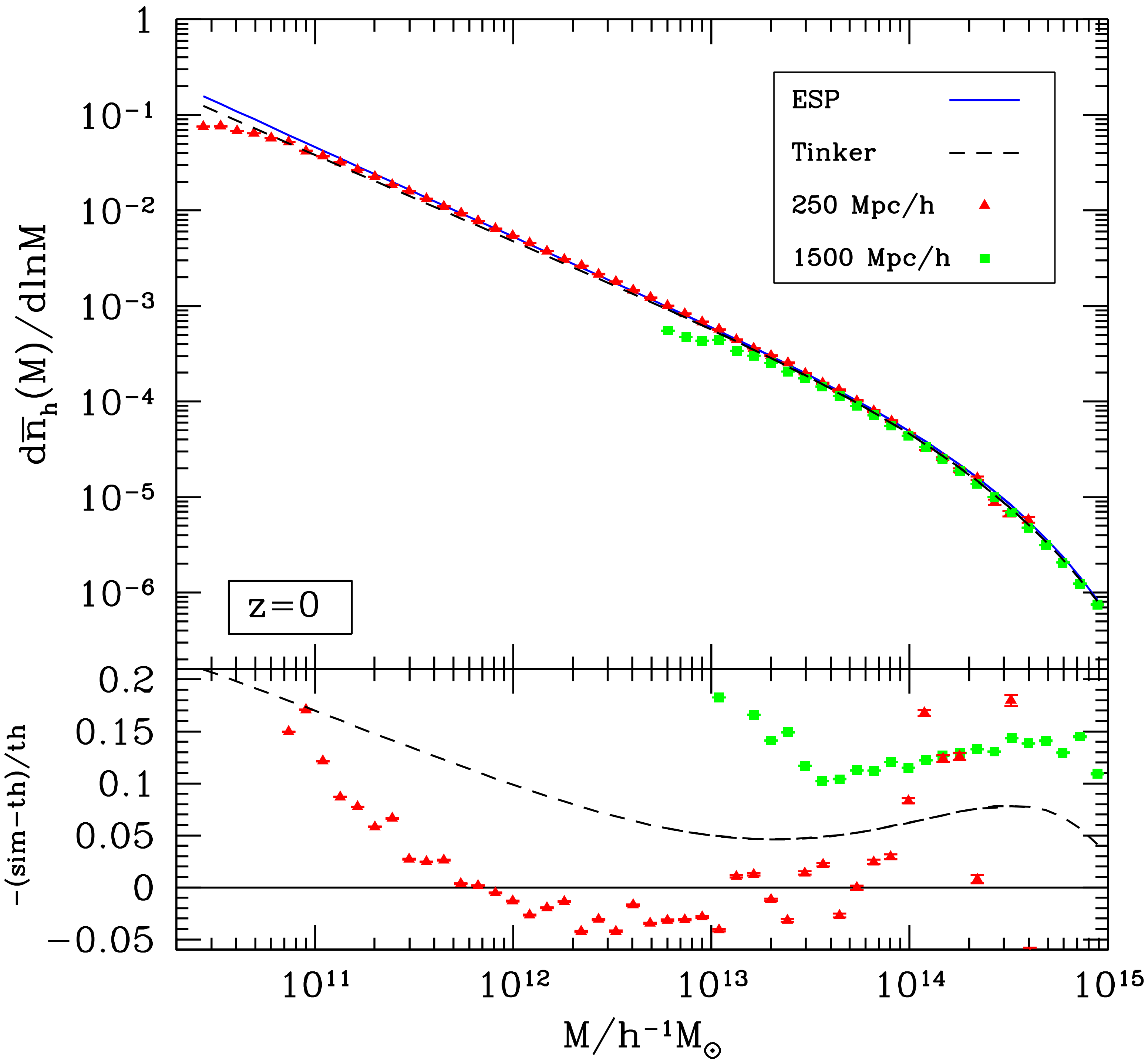
$$B(\sigma_0) = \delta_c + \beta\sigma_0$$

stochastic variable
log-normally distributed

where $\sigma_n^2 = \frac{1}{2\pi^2}\int_0^\infty \mathrm{d}k\, k^{2(n+1)} P_s(k)$ $\nu_c = \frac{\delta_c}{\sigma_0}$

$\Delta b_1(k) \propto 2 f_{\rm NL}\frac{b_{\rm NG}}{k^2}$

Fourth step: ESP



MB, Chan, Desjacques & Paranjape, Mon.Not.Roy.Astron.Soc. 441 (2014) 1457-1467

$$\Delta b_1(k) \propto 2 f_{\mathrm{NL}} \frac{b_{\mathrm{NG}}}{k^2}$$

Fourth step: ESP

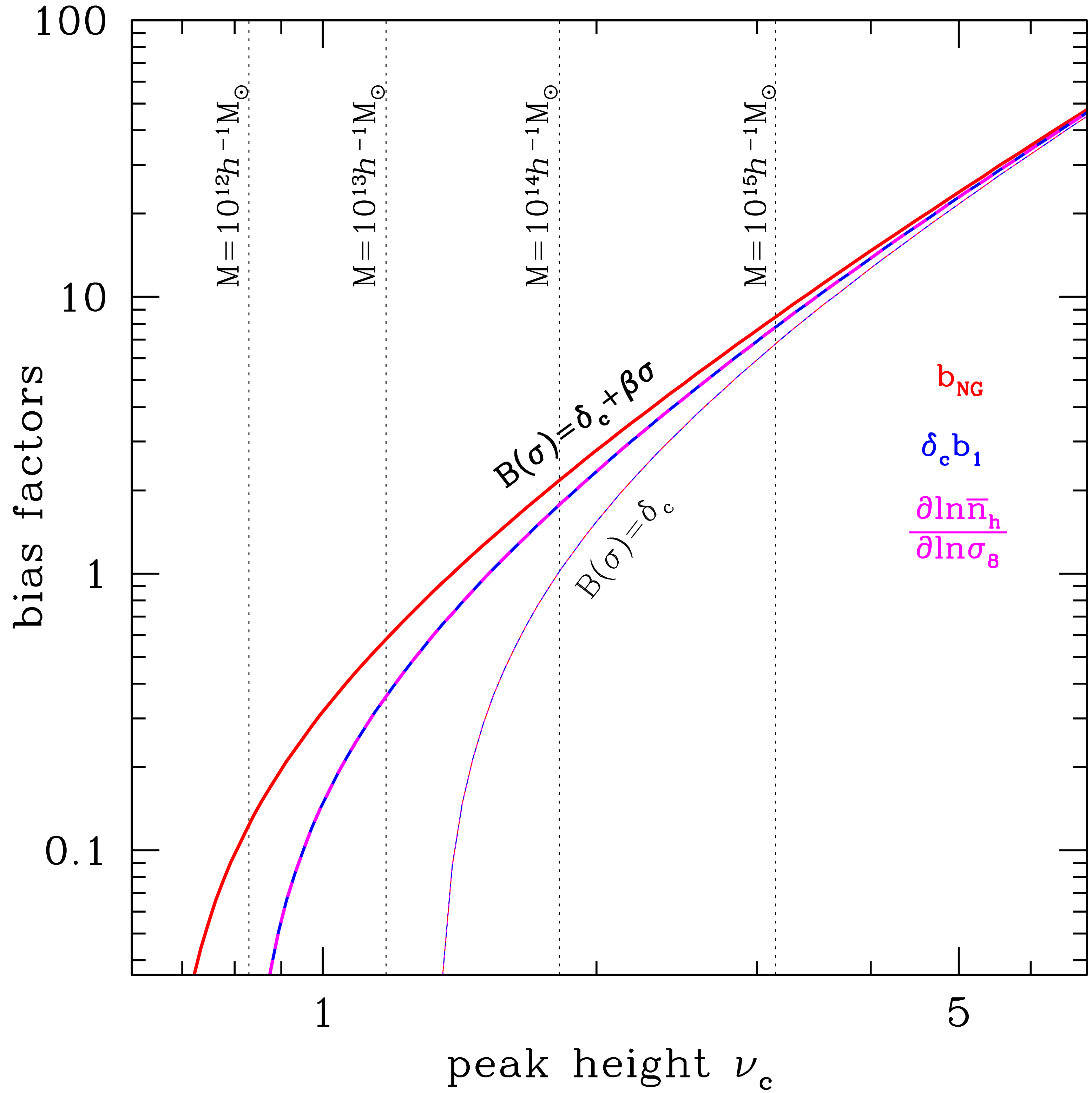
When we compute the PNG effect on the scale dependent bias for ESP, we get

$$b_{\rm NG}^{\rm ESP} = \begin{cases} \xrightarrow[\text{constant barrier}]{B(\sigma)=\delta_c} \dfrac{\partial \ln \bar{n}_h}{\partial \ln \hat{\sigma}_8} \equiv b_{NG}^{\rm PBS} \\ \xrightarrow[\text{moving barrier}]{B(\sigma_0)=\delta_c+\beta\sigma_0} \sigma_0^2 b_{200} + 2\sigma_1^2 b_{110} + \sigma_2^2 b_{020} + 2\sigma_1^2 \chi_{10} + 2\sigma_2^2 \chi_{01} + \Delta_0^2 b_{002} - (\sigma_0^2)' b_{101} - (\sigma_1^2)' b_{011} \neq b_{NG}^{\rm PBS} \end{cases}$$

$$\Delta b_1(k) \propto 2 f_{\rm NL} \frac{b_{\rm NG}}{k^2}$$

Desjacques, Gong & Riotto, JCAP 1309 (2013) 006

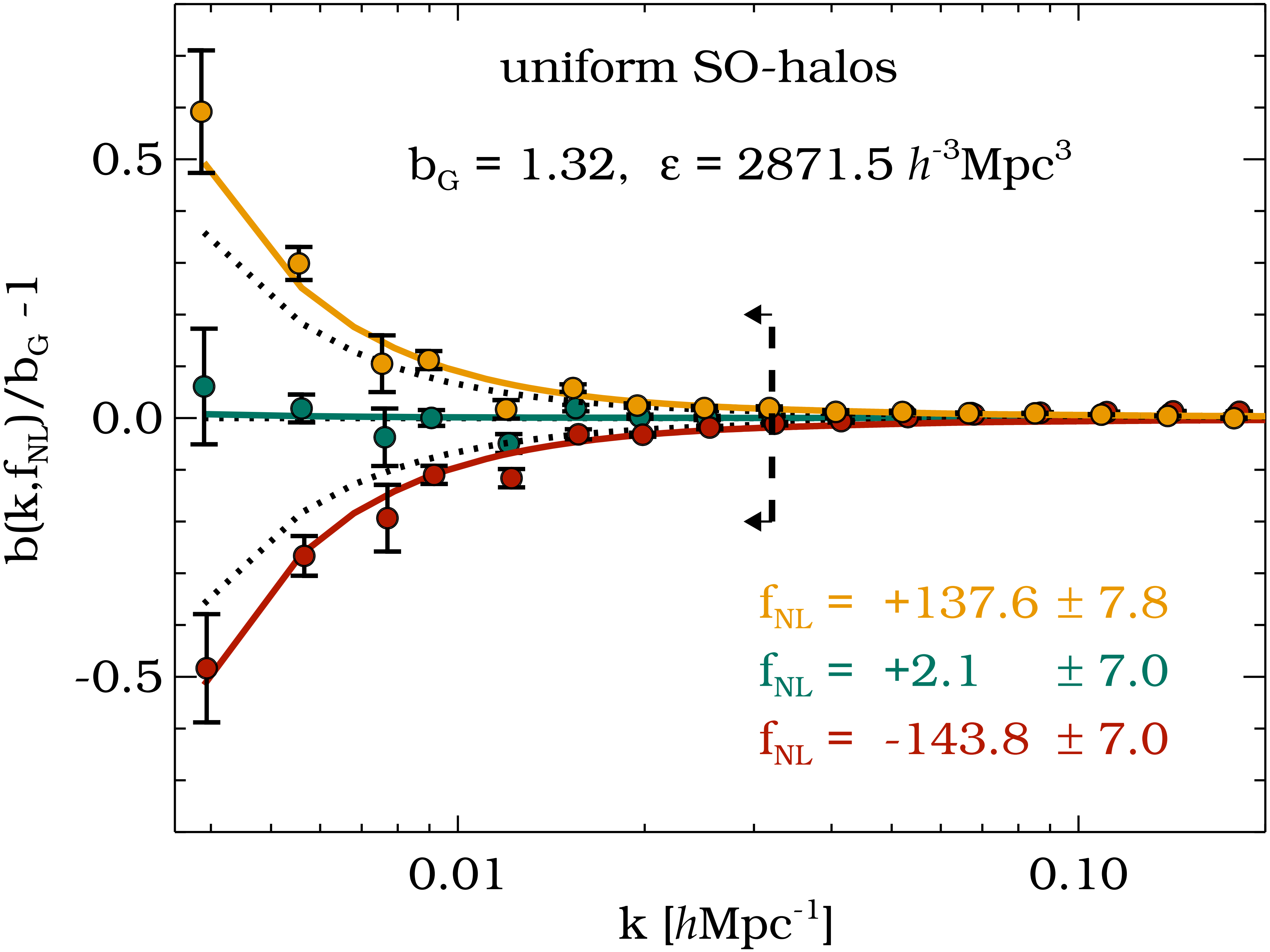
Fourth step: ESP



MB, Desjacques, arXiv: 1502.04982

$$\Delta b_1(k) \propto 2 f_{\rm NL} \frac{b_{\rm NG}}{k^2}$$

Fourth step: ESP



Hamaus, Seljak & Desjacques, Phys.Rev. D84 (2011) 083509

$$\Delta b_1(k) \propto 2 f_{\rm NL} \frac{b_{\rm NG}}{k^2}$$

Take home message

Information about PNG will come from LSS and more specifically (mostly) from the scale dependent bias signature

If this information is not correctly theoretically modelled, it may be not correctly interpreted

Take home message

ESP model predicts a signal in contrast up to 40% wrt PBS approach: this needs to be settled

N-body simulations will be used to measure this effect